

# New BPM System for PETRA IV

Summary of the bachelor thesis  
of Jonas Lamaack

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HELMHOLTZ



# Agenda

## **01 Introduction**

- History of PETRA
- PETRA IV

## **02 New BPM system**

- Requirements
- System overview

## **03 Measurements**

- Setup
- Results and evaluation

## **04 Conclusion**

- Summary and outlook

# PETRA is evolving since 1978

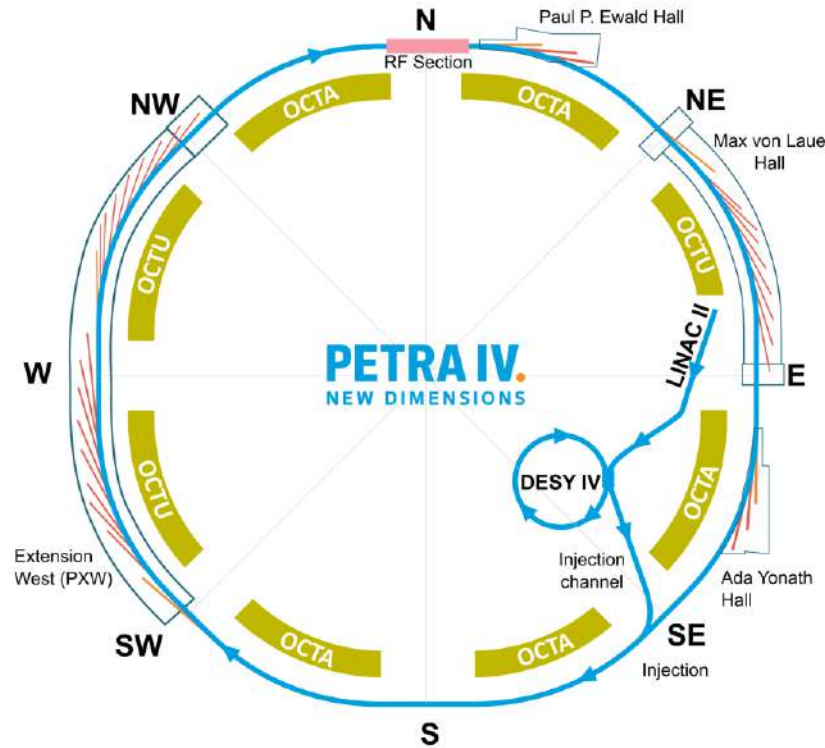
Positron Electron Tandem Ring Accelerator - PETRA

- 1978 – 1986: e+e- collider PETRA
- 1988 – 2007: pre-accelerator PETRA II for HERA
- since 2009: 3<sup>rd</sup> generation light source PETRA III
- at present: work on PETRA IV project





# PETRA IV will be a significant upgrade



Design parameter	PETRA III		PETRA IV	
	Continuous	Timing	Brightness	Timing
Operation mode	Continuous	Timing	Brightness	Timing
Energy / GeV	6		6	
Circumference / m	2304		2304	
Emittance (horz. / vert.) / pm rad	1300 / 10		< 20 / 4	< 50 / 10
Total current / mA	100		200	80
Number of bunches	960	40	1600	80
Bunch current / mA	0.1	2.5	0.125	1.0

PETRA IV Conceptual Design Report

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# PETRA IV imposes requirements on the BPM system

- ~800 Beam Position Monitors (BPMs)
- Long thermally uncontrolled cables  
→ External Crossbar Switching (ECS)

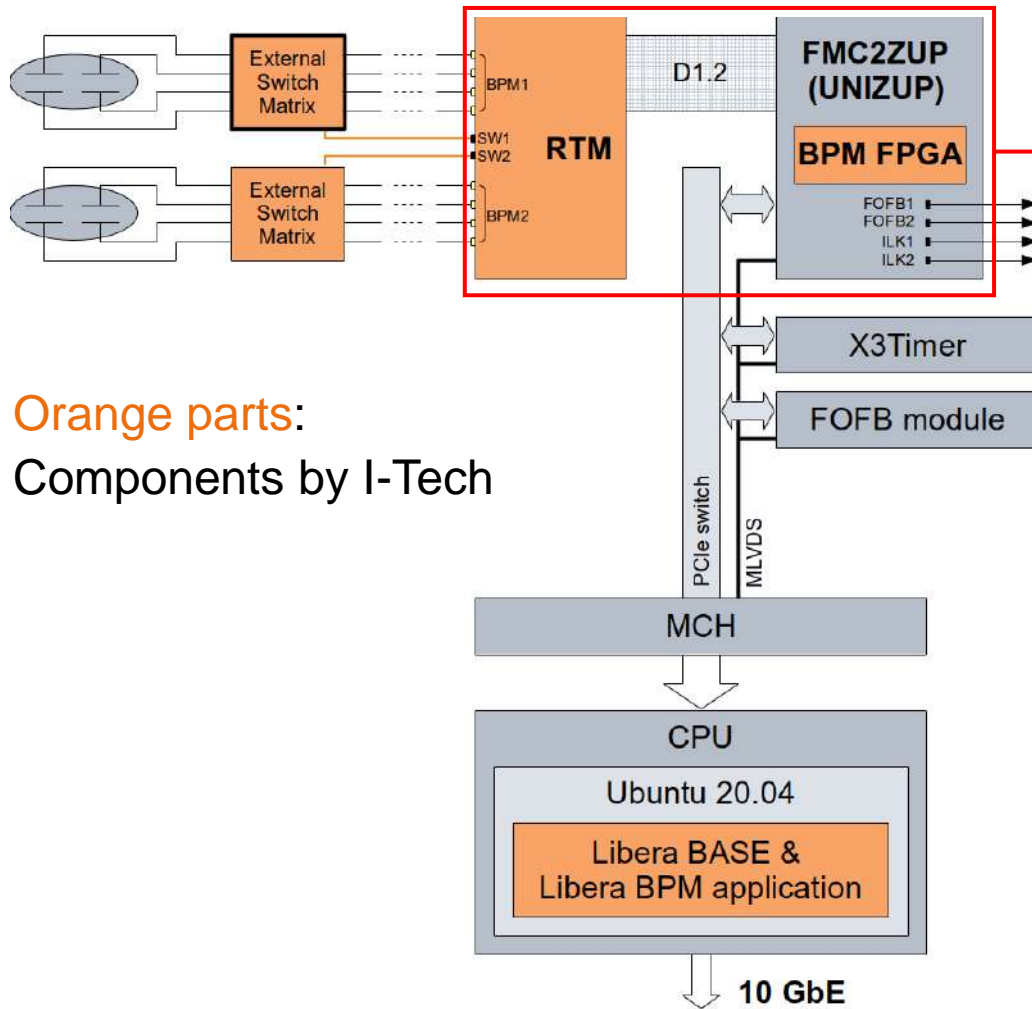
Long-Term Stability:	< 1 $\mu\text{m}$ change over 6 days
Closed Orbit Resolution:	< 100 nm for 1 kHz bandwidth
Beam Charge Dependency:	< $\pm 2$ $\mu\text{m}$ over 60 dB range
Single Turn Resolution:	< 30 $\mu\text{m}$ rms for Single Pass Injection

Disclaimer:

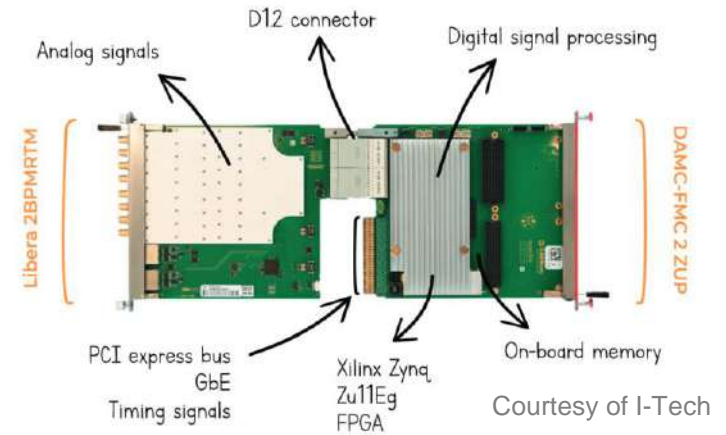
Presented work was done by

**Jonas Lamaack**

# The new BPM system uses MicroTCA.4



Orange parts:  
Components by I-Tech



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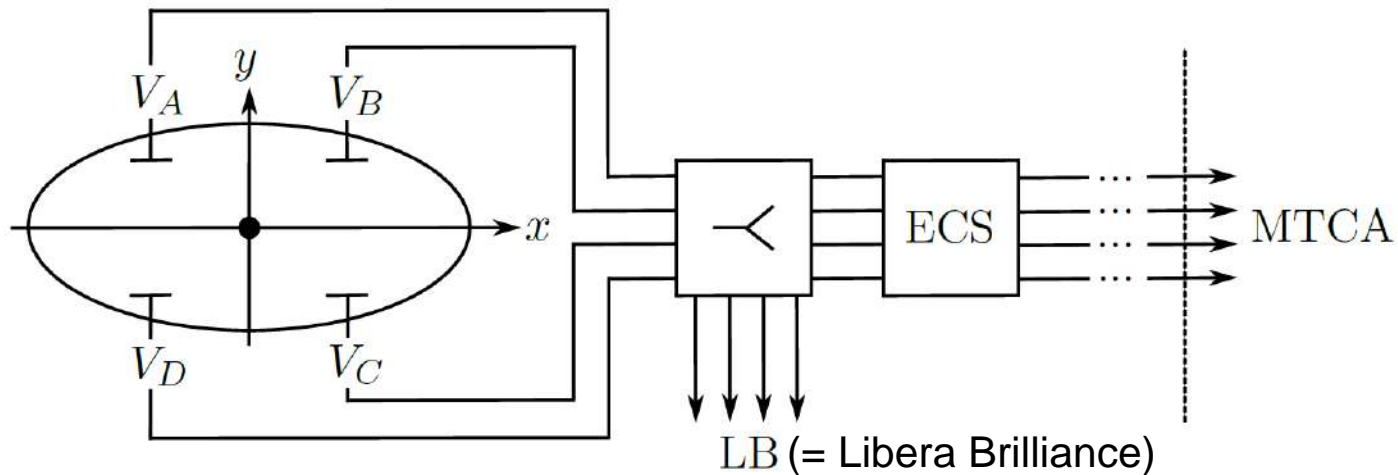
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# Live measurements are conducted in PETRA III



$$x = K_x \frac{(V_A + V_D) - (V_B + V_C)}{\Sigma} \quad y = K_y \frac{(V_A + V_B) - (V_C + V_D)}{\Sigma}$$

Measurements:  $K_{x,y} = 10 \text{ mm}$     PETRA IV:  $K_{x,y} < 10 \text{ mm}$

# The BPM system was installed in PETRA III



Switch Matrix below BPMs

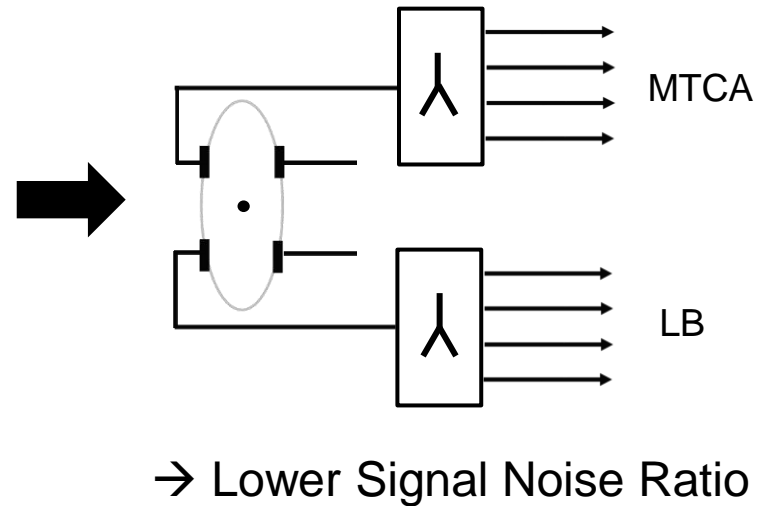
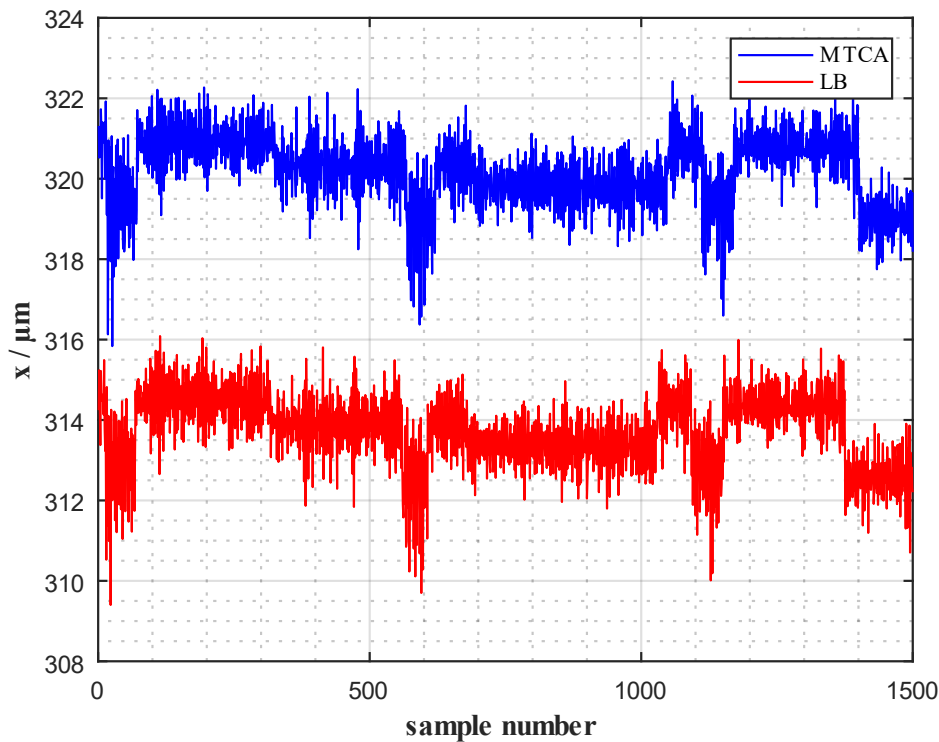


MicroTCA crate front ↑ and rear ↓

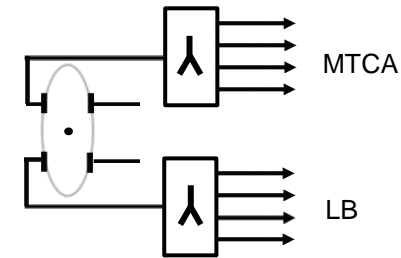


# 4-way splitter setup eliminates beam motion influence

$f_s = 10 \text{ Hz}$

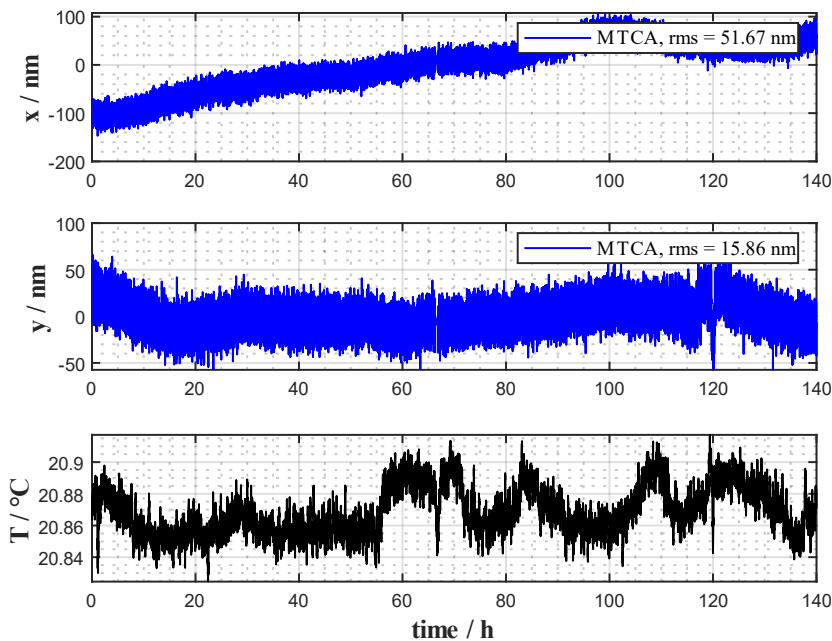


# Long-Term Stability is sufficient

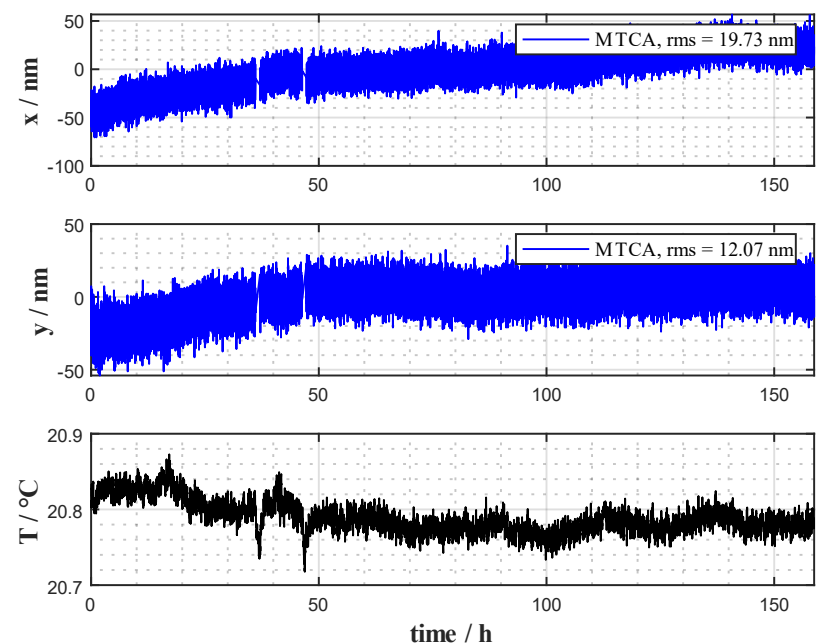


- Requirement:  $< 1 \mu\text{m}$  change over 6 days

480 bunches at 120 mA

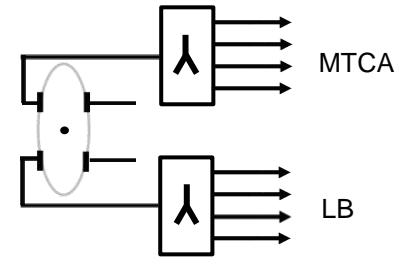


40 bunches at 100 mA



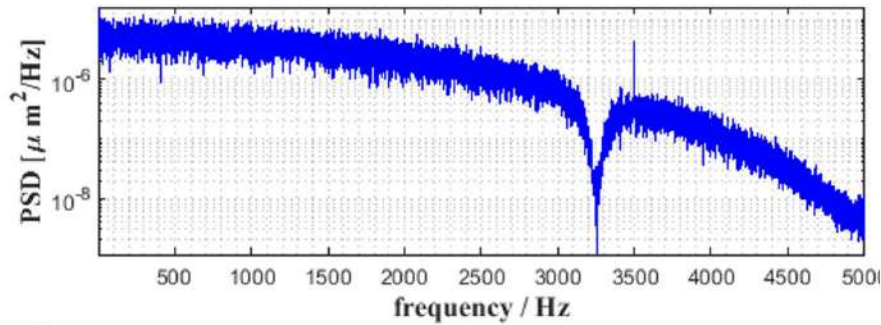
Temperature measured on Switch Matrix

# Closed Orbit Resolution sufficient in 480 bunch mode

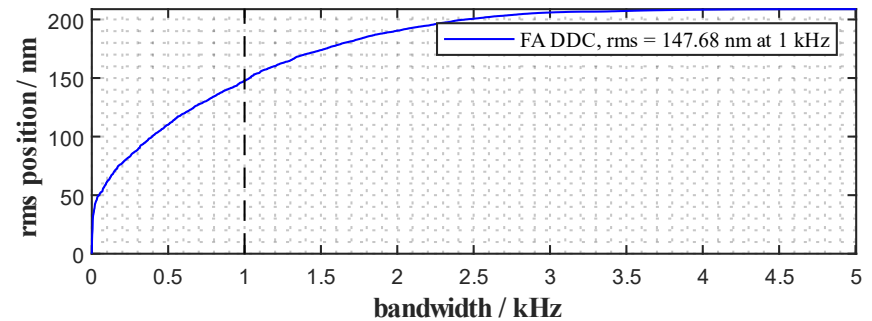
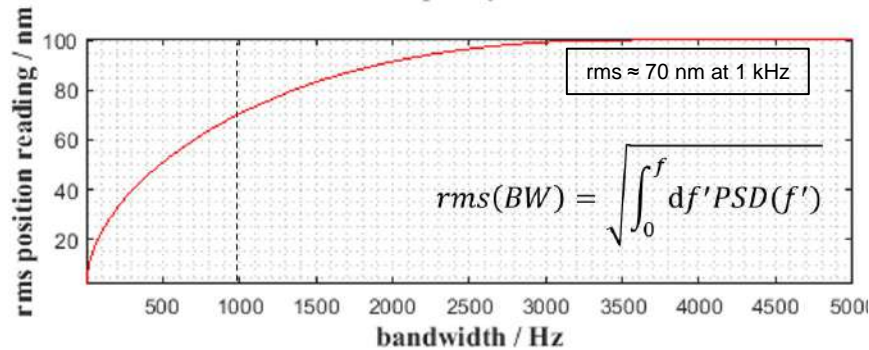
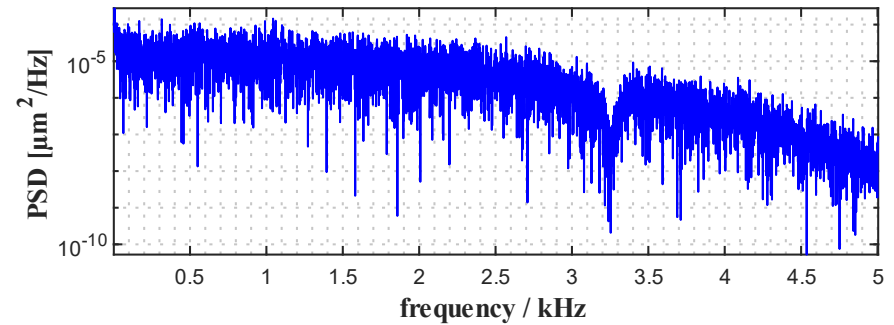


- Requirement: < 100 nm for 1 kHz bandwidth

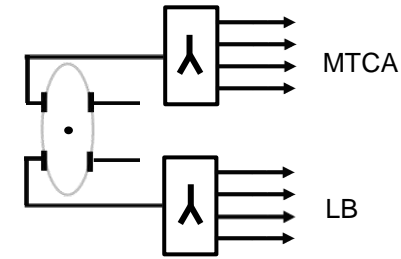
480 bunches at 120 mA



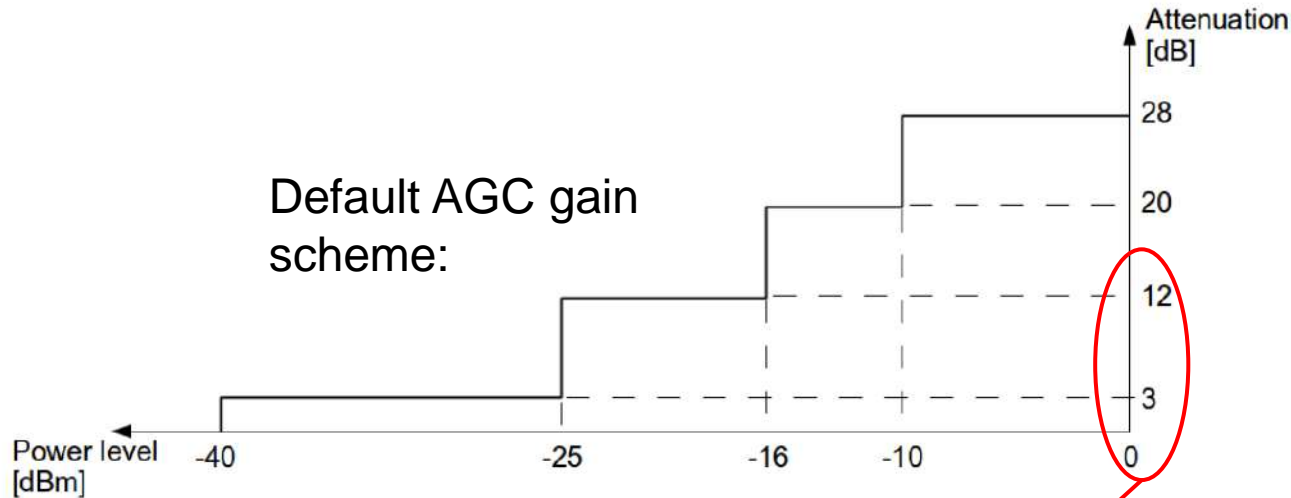
40 bunches at 100 mA



# Closed Orbit Resolution improves with adapted gain scheme



- Requirement:  $< 100$  nm for 1 kHz bandwidth

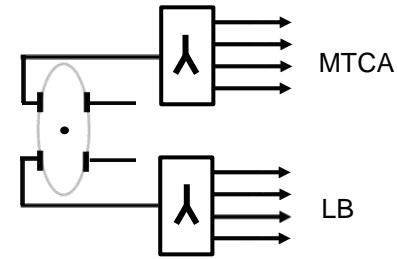


AGC disabled:

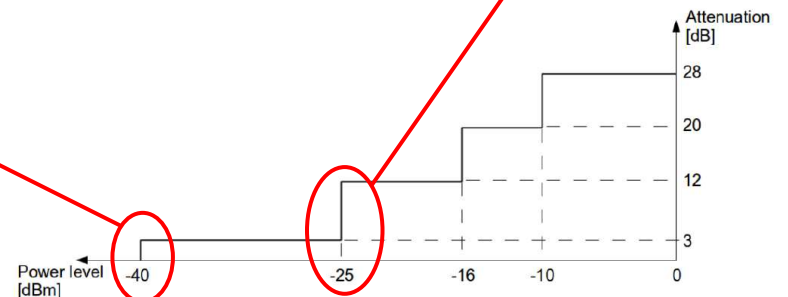
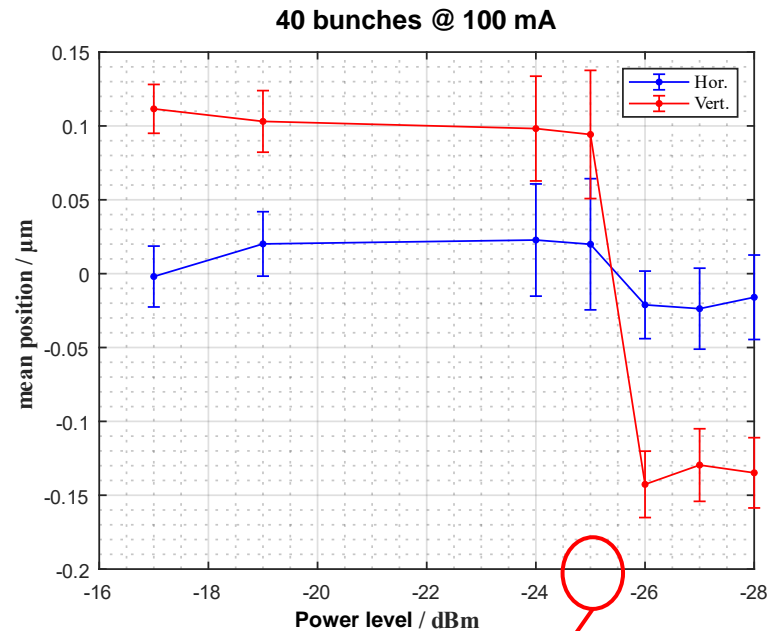
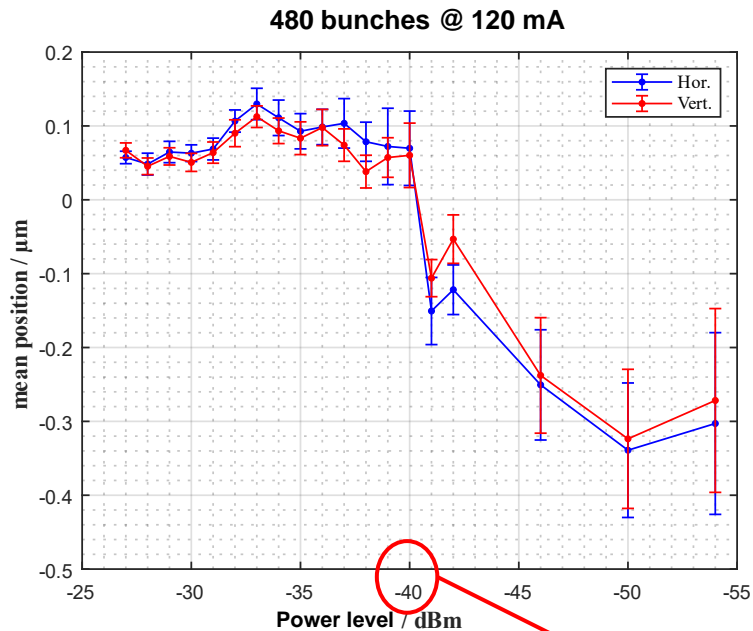
rms [nm]	Max. ADC count	Attenuation [dB]
148.70	5000	12
85.33	14000	3
84.87	19000	0



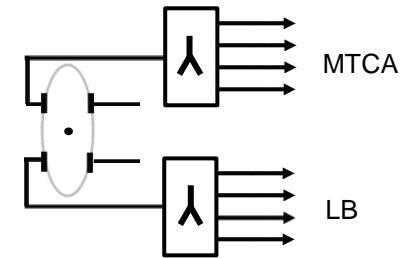
# Beam Charge Dependency is sufficient within 37 dB range



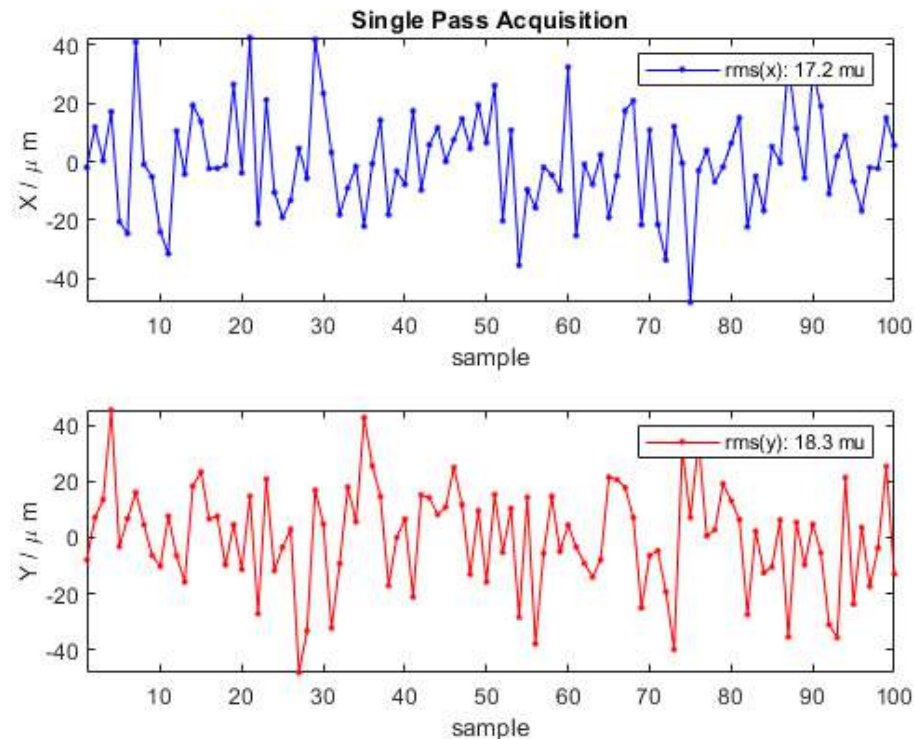
- Requirement:  $< \pm 2 \mu\text{m}$  over 60 dB range



# Single Turn Resolution is sufficient



- Requirement:  $< 30 \mu\text{m}$  rms for Single Pass Injection
- Operation mode:  
A single bunch that is dumped after one turn



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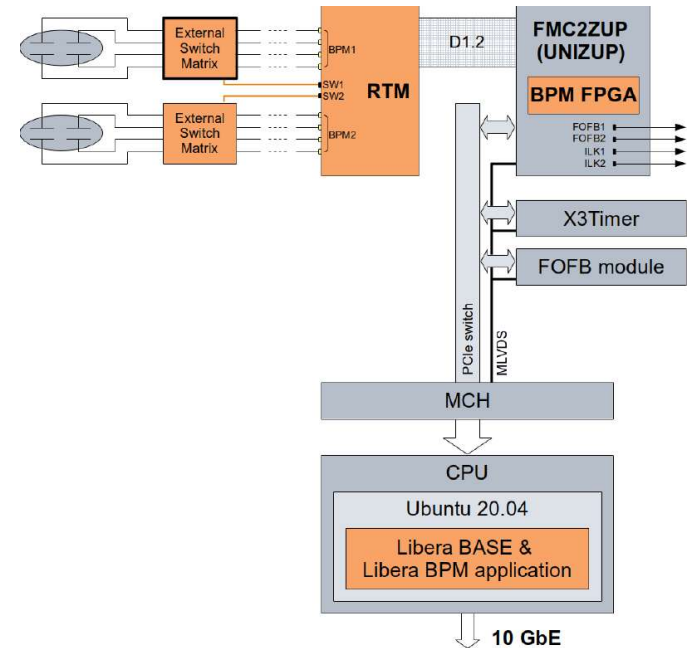
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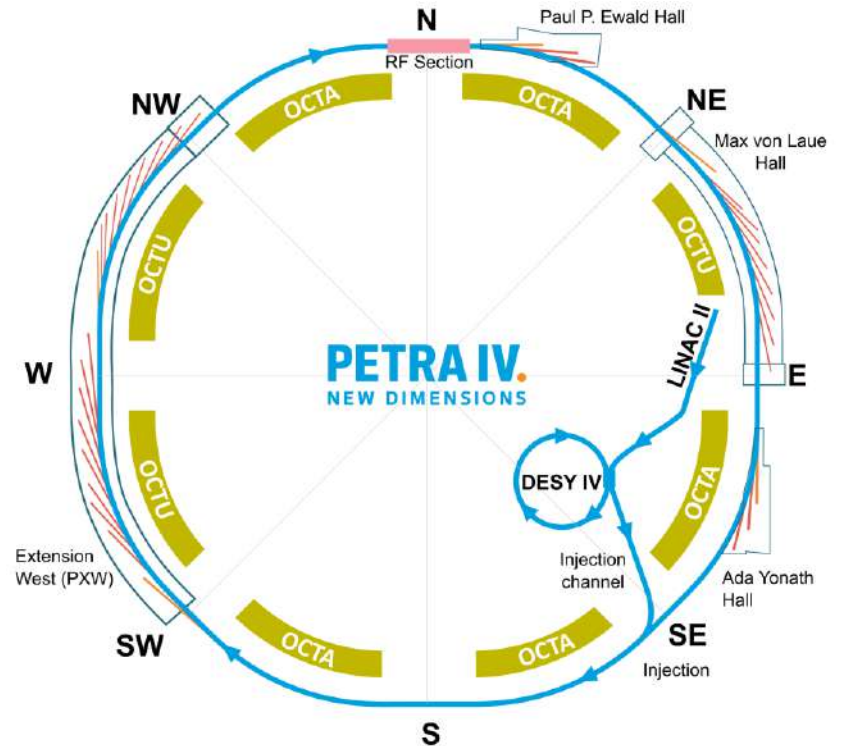
# The new BPM system meets requirements of PETRA IV

- New BPM system for PETRA IV introduced  
→ Based on MicroTCA.4, added ECS
- Requirements fulfilled for  $K_{x,y} = 10$  mm  
→ AGC gain scheme will be adapted



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# Thank you



## Contact

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